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USE OF OFF-GRADE INITIAL MATERIALS IN GLASS PRODUCTION

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The operation of the glass making and production system at the Irbit Glass Works, using off-grade raw materials and a method for affecting the glass making and production process, is examined.

The stability of the technological process of glass making largely depends on the quality and uniformity of the initial materials used. For decades now the glass works in our country have used traditional, quality-standardized, initial materials. The chemical compositions of and content of foreign impurities in these initial materials have been relatively stable. The main glass-forming natural initial materials (dolomite and quartz sand) contained negligible quantities of impurities, such as, for example, the oxides of iron, chromium, titanium, and others, which had no effect on the technological process of making glass articles.

The content of the harmful impurities in the traditionally used initial materials in most cases was regulated within definite limits and predictable.

However, because the economic conditions in our country have changed and the quartz sand and dolomite deposits are located far from glass works, for glass production it has became necessary to use initial materials from local deposits. Such initial materials contain impurities which have a negative effect on the glass making process and the quality of the manufactured product. In addition, the main composition of these materials is unstable, which, in turn, disrupts the technological process and results in product rejection.

According to published data and analyses performed at the company's laboratory, sand from the Alapaevskoe deposit contains impurities which impart undesirable color to sheet glass and have a negative effect on the glass making and production process: chromium oxide — up to 0.002%,[2] titanium oxide 0.2 – 0.8%, iron oxide — up to 0.5%. Metallurgical dolomite contains other heterovalent forms of elements besides iron oxides.

It is impossible to limit chromium and titanium oxide impurities under production conditions, but iron oxides and their heterovalent forms can be regulated [1 – 3].

When the technological process (temperature regime) is stable and the chemical composition of the glass mass is constant, iron oxides are responsible for the change in the diathermancy of the glass mass, disruption of the glass making regime, and the formation and degradation of the quality of the finished product. Consequently, the content and ratio of heterovalent forms of iron in the glass mass must be regulated and the required adjustments must be made in order to stabilize the glass production process, i.e., on-line control of the content of heterovalent forms of iron during the making process becomes necessary [4, 5].

The valence of iron in glass is variable, but the bivalent iron compound FeO, which passes thermal radiation more weakly in the molten glass mass, has the strongest effect on the glass making and production process. Fluctuations of the equilibrium between FeO and Fe_2O_3 iron disrupt the fining process. Changes in the diathermancy of the melt decrease the temperature of the bottom layers and make the glass mass nonuniform in the bulk of the product stream, thereby destroying its thermal uniformity.

The technological regime of glass making and production, specifically, the diathermancy of the glass mass, can be stabilized by establishing the optimal equilibrium between the heterovalent forms of iron — FeO and Fe_2O_3. When initial materials which come from local or different deposits and contain unregulated amounts of impurities (including organic) which are harmful for glass making, iron and chromium oxides, are used the indicated equilibrium shifts, and this has a strong effect on the glass making and production regime.

When the content of these impurities is not monitored and the appropriate measures are not instituted at the right time the diathermancy of the glass mass changes, and as a result defects, such as course striping and cords, appear in the glass, and for inadmissible values of FeO and the ratio FeO : Fe_2O_3 an abnormal decrease of the temperature occurs

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[2] Here and below — the weight content.

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TABLE 1.

Month	Weight content, %		$FeO : Fe_2O_3$*	Glass mass utilization factor
	Fe_2O_3	FeO		
1	0.164	0.026	25	0.884
2	0.156	0.026	27	0.870
3	0.160	0.027	28	0.871
4	0.154	0.025	26	0.836
5	0.155	0.026	27	0.832
6	0.155	0.026	27	0.787
7	0.156	0.025	26	0.839
8	0.160	0.026	25	0.790
9	0.166	0.026	25	0.810
10	0.153	0.024	26	0.830
11	0.147	0.023	27	0.880
12	0.136	0.022	28	0.880
One-year average	0.155	0.025	26	0.847

* Standard value — 25 – 26%.

at the bottom of the glass mass in the zone of the maximum, chilling occurs, and the conditions for glass ribbon formation are disrupted.

If immediate measures to normalize these indicators are not taken, a rough disruption of the entire glass making process occurs. For example, when sand and dolomite from the Ural region that have an inadmissible content of impurities which are harmful for glass making, including iron oxide (0.4 – 0.5 and 0.2 – 0.3%, respectively), were used in production, the amount of FeO in the glass mass was 0.039 – 0.043%, the total amount of iron was 0.14 – 0.16%, and the ratio $Fe : Fe_2O_3 = 34 – 39\%$. Coarse striping and fracturing on glass ribbons and sharp drops of the temperature of the domes (> 40°C) and at the bottom of the chilling zone (> 20°C) were observed. However, in another case with the same content of iron oxides and a large amount of FeO but with the optimal ratio $FeO : Fe_2O_3$ the operation of the glass making and production system was stable and efficient (see Table 1).

In summary, to manufacture glass articles it is necessary not only to have information on the total content of iron oxides but it is also very important to have running data on the content of the individual iron oxides FeO and Fe_2O_3 and their ratio in the glass mass, on the basis of which timely adjustments can be made to the redox potential of the glass mass [6 – 8]. Therefore, to stabilize the technological process, specifically, to optimize the diathermancy and redox potential of the glass mass, it is necessary to have an on-line method of monitoring and influencing the glass making and production process.

The method developed at the Irbit Glass Works for performing on-line monitoring of the redox potential of the glass mass makes it possible to stabilize the diathermancy of the melt. The data obtained over the last 12 years confirm the effect of the $FeO \leftrightarrow Fe_2O_3$ equilibrium in the glass mass on and its importance for the glass making and production system.

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